



Jet Propulsion Laboratory
California Institute of Technology

Welcome to ESTF:

JPL's Earth Science Vision for Next Decade

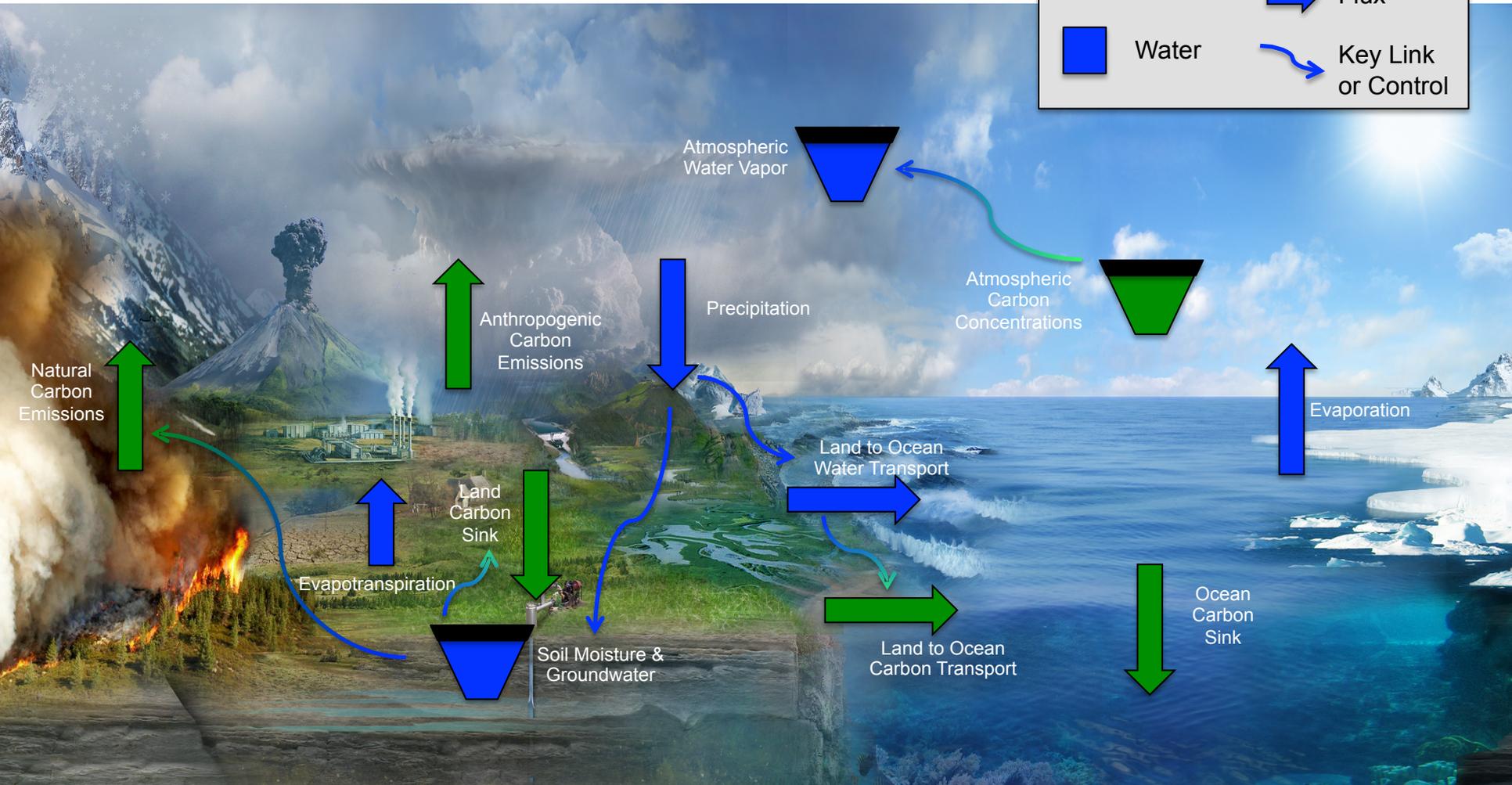
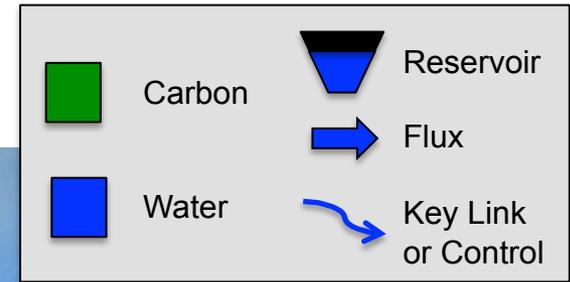
Diane Evans, Director

ESTD

June 13, 2017

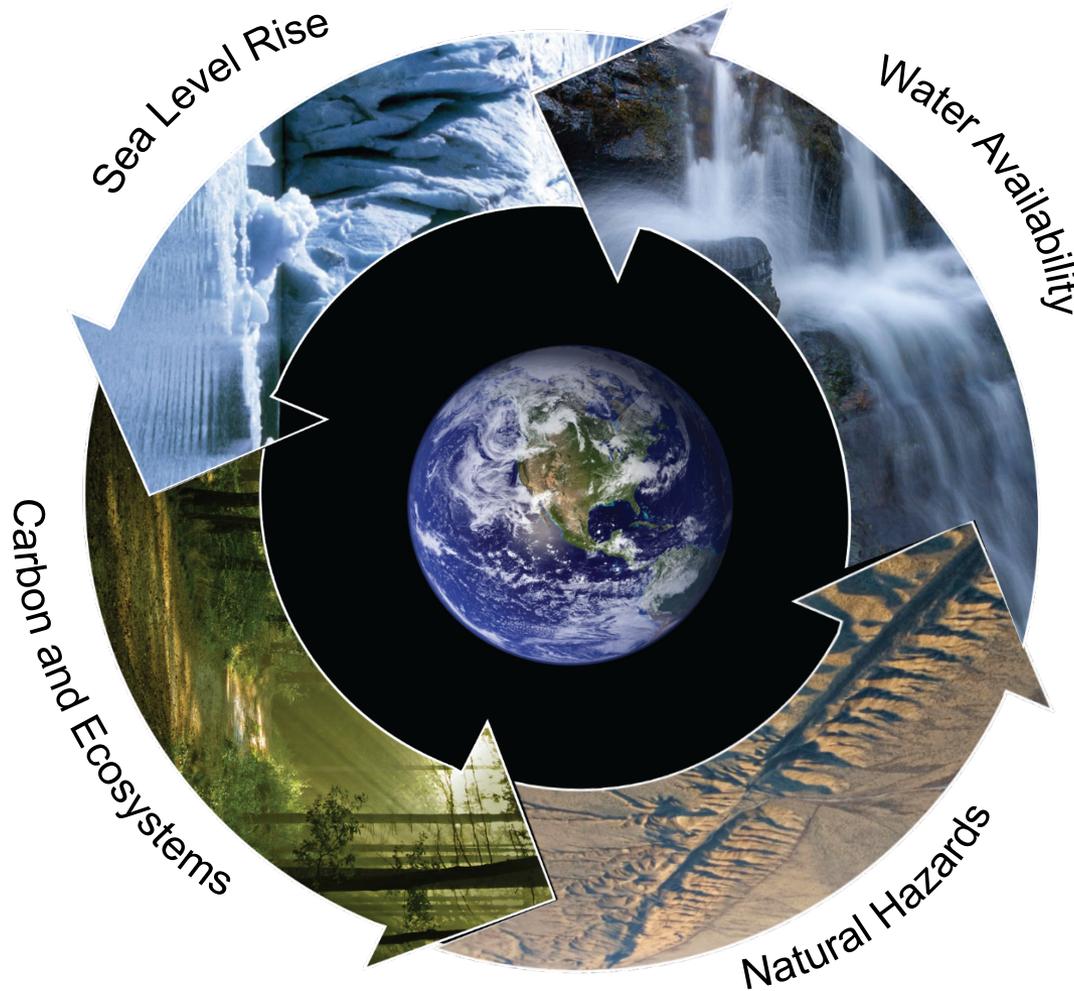
Our Complex Planet

Legend



Earth Science Grand Challenge

Making Earth's Complexity Tractable



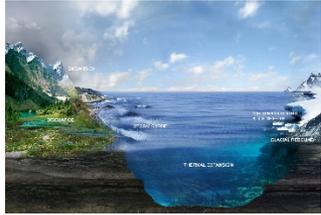
Combining system engineering expertise with advanced technologies and science expertise to provide reliable and accurate information

Our Quests:

To Understand How Our Planet Is Changing

To Use Our Unique Technical Expertise to Serve Our Nation and Its People

Sea Level



Improve long-term projections of regional sea level rise and the consequences to urban populations and natural ecosystems.

Water



Forecast water shortages 2 weeks, 2 months, and 2 years in advance with quantifiable uncertainties.

Carbon



Improve projections of global food security, forest health & disturbance and biodiversity, as well as the climate and ecosystem responses to anthropogenic forcing agents (e.g. CO₂ & CH₄).

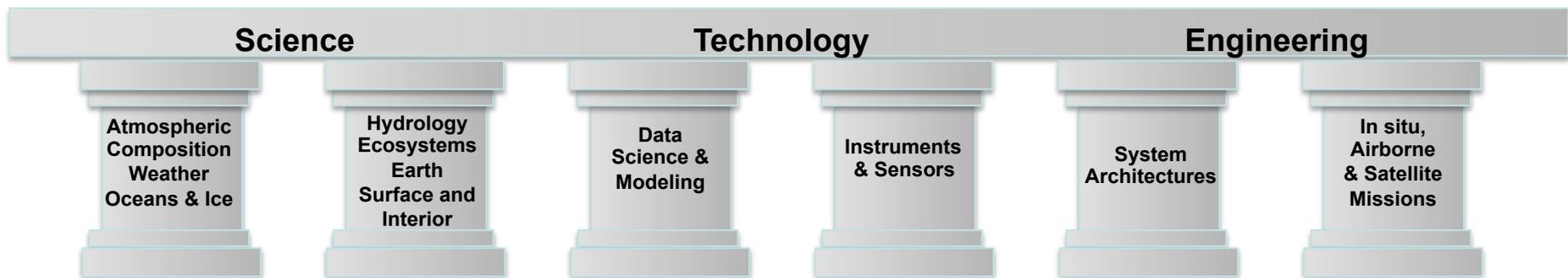
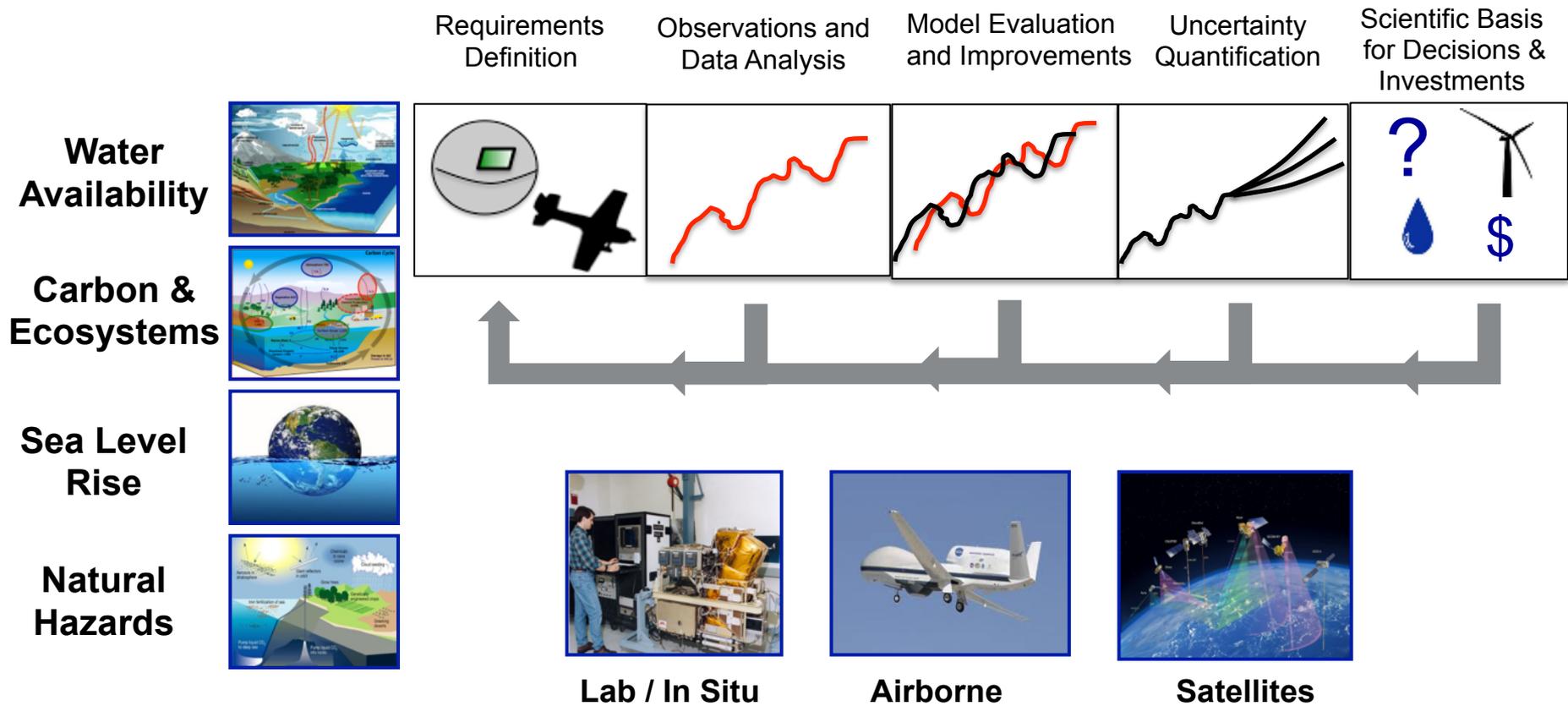
Natural Hazards



Increase the lead-time for solid earth, weather and air quality hazards and improve our capabilities for hazard response and preparedness.

JPL Earth Science

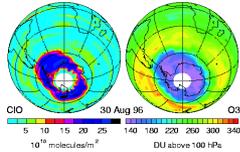
From Science to Actionable Information



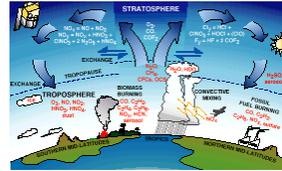
Atmospheric Composition & Air Quality

Technology Observations Results

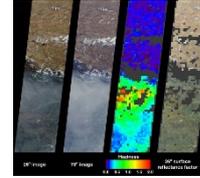
Chlorine Monoxide and the Ozone Hole: 1996
measured by UARS MLS



Ozone Depletion & Recovery



Global-Regional Pollution



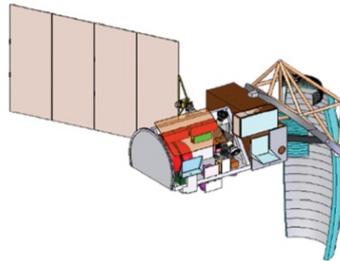
Aerosol Classification



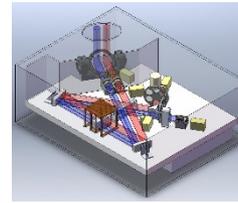
Cloud-Aerosol Interactions



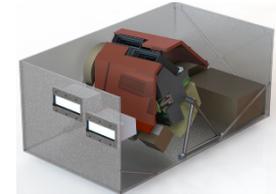
Water Vapor & Temperature



Stratospheric Chemistry



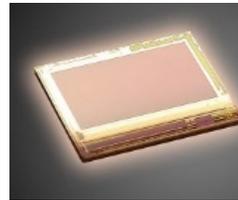
Tropospheric Chemistry



Aerosols



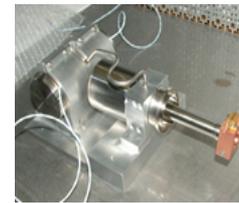
Compact Spectrometer



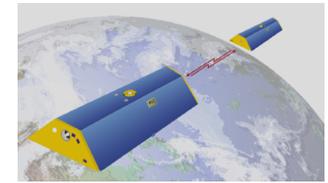
High QE FPA, Grating, and Slits



Submm/mm Sensors



Advanced Cryo-coolers

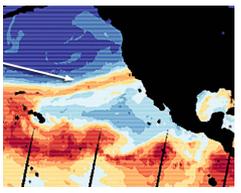


Formation Flying

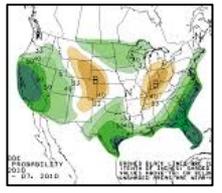
Weather



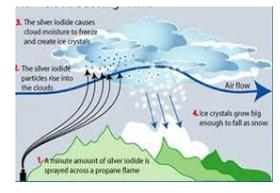
Drought



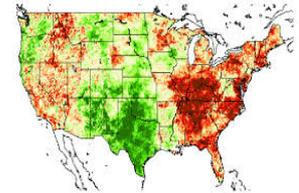
Precipitation
Extremes



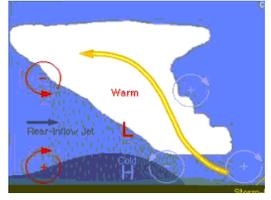
S2S
Forecasting



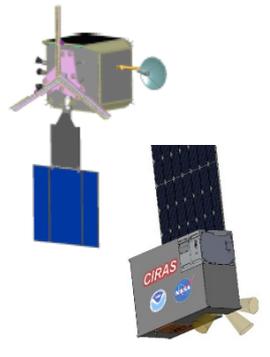
Cloud-Aerosol
Interactions



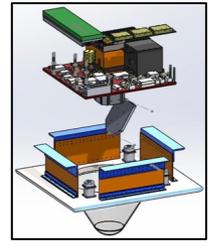
Evapotranspiration



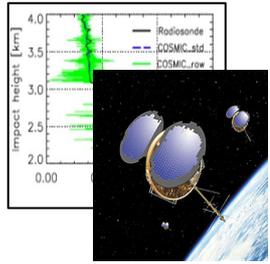
Severe Storms



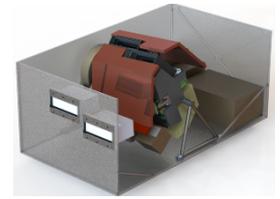
Convection &
Water Vapor



Winds



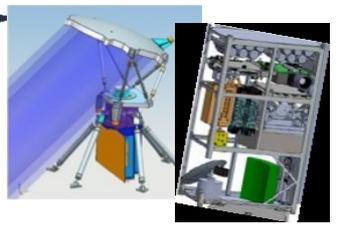
Boundary
Layer



Aerosols



Precipitation



Temperature
& Clouds



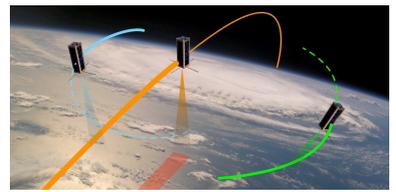
Passive
Microwave



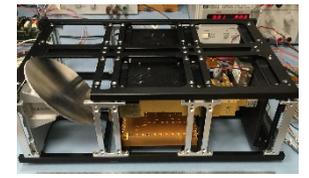
Submm/mm
Sensors



Radars

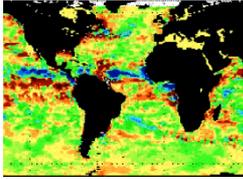


Formation Flying

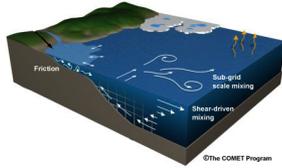


Miniaturization for
CubeSats

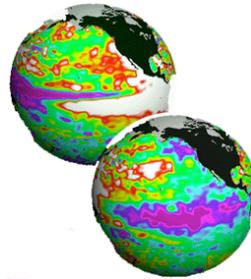
Oceans and Ice



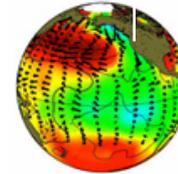
Evaporation rates



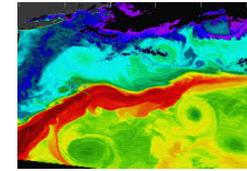
Ocean Acidification Heat and Carbon Sequestration



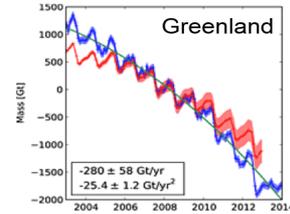
El Niño/ La Niña



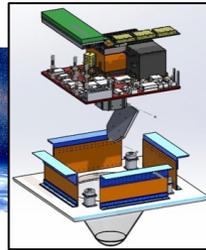
Pacific Decadal Oscillation



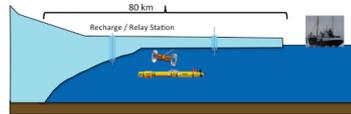
Mesoscale Dynamics



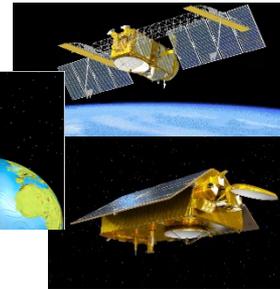
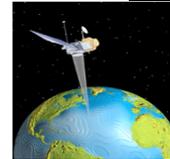
Ice Sheet Mapping



Ocean Currents & Vector Winds



MLD & Ocean Bio/ Geo/Chem



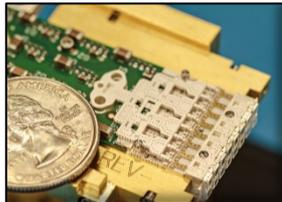
Ocean Topography



Ice Motion and Mass



Time-varying Gravity Field



Active Microwave sensors



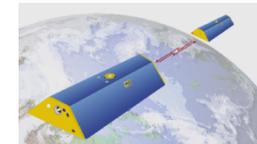
Advanced GPS technologies



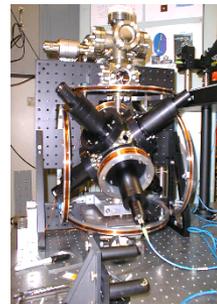
Autonomous Navigation & Sampling



Precision Structures



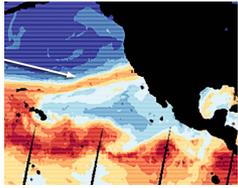
Precision formation flying



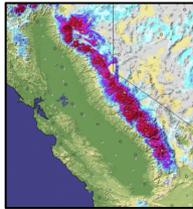
Quantum devices

Hydrology

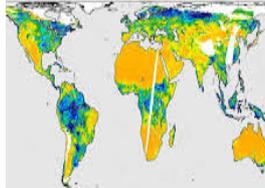
Results
Observations
Technology



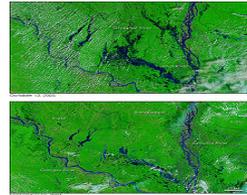
Precipitation
Extremes



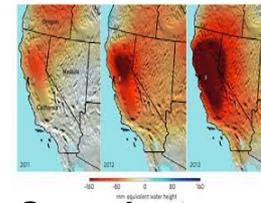
Snow Pack



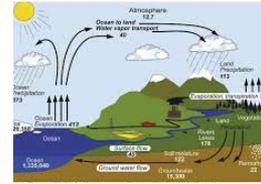
Drought



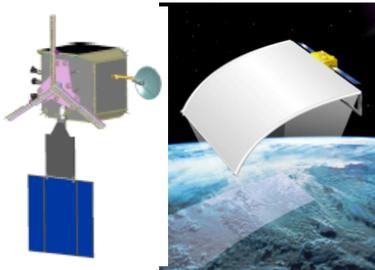
Flood &
Inundation



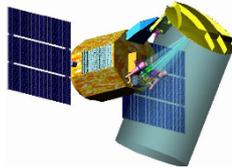
Groundwater
Extraction



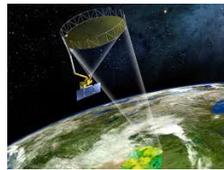
Water Cycle
Science



Precipitation



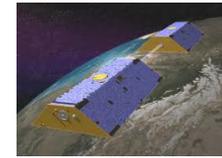
Snow Water
Equivalent



Soil Moisture



Surface Water
Heights



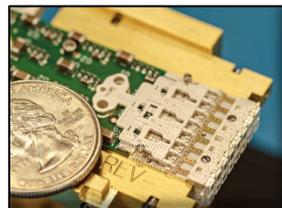
Gravity



Evapotranspiration



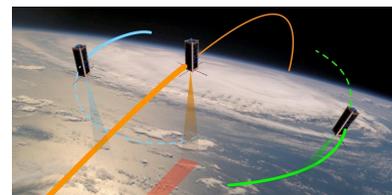
Passive Microwave



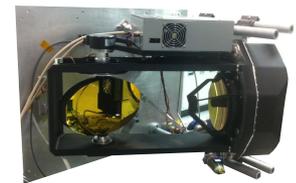
Active Microwave
Sensors



Advanced
Cryo-coolers

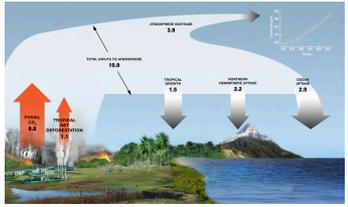


Formation Flying

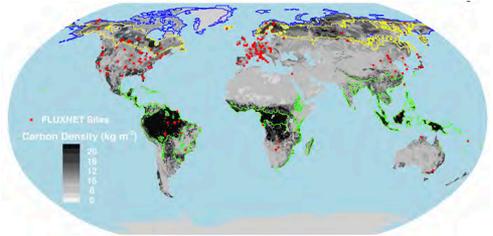


TIR Sensors
& Compact
spectrometers

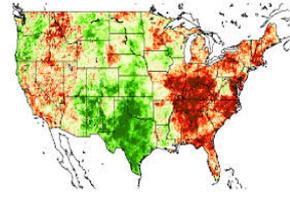
Ecosystems



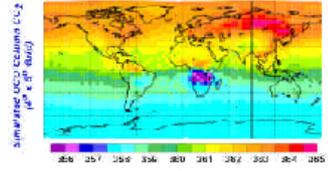
Carbon Fluxes and Feedback



BioDiversity



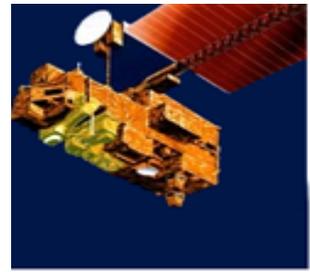
Plant/Crop Stress



Carbon Cycle



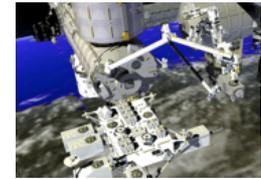
Biomass (InSAR)



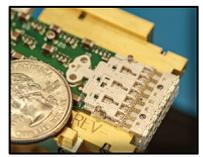
Plant Health & Function (Hyperspectral Imaging)



Evapotranspiration (IR Spectral Imaging)



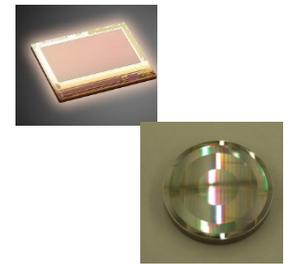
Greenhouse Gases



Active Microwave Sensors



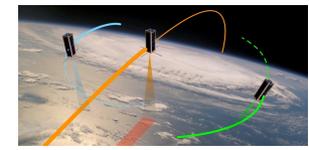
TIR Sensors & Compact spectrometers



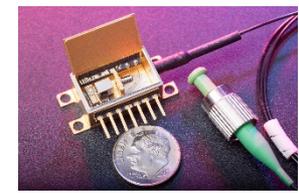
Compact Spectrometer & Adv. FPA



Advanced Cryo-coolers



Precision Formation flying



Lidar

Earth Surface and Interior

Results

Observations

Technology

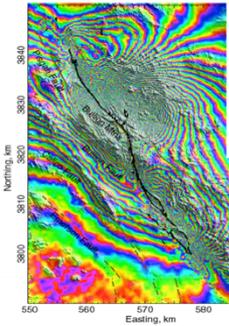
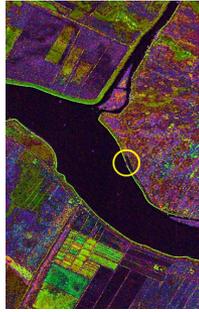
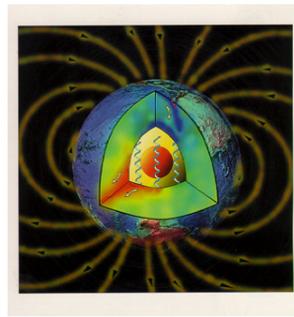


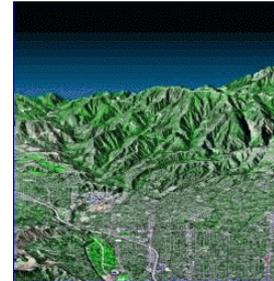
Plate Boundaries



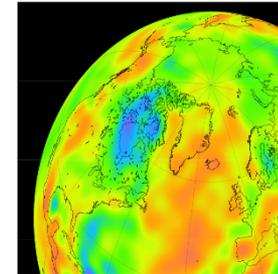
Human Activities



Magnetic Field



Land Surface Change



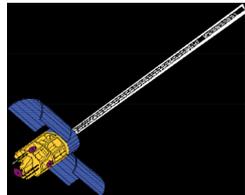
Mantle Dynamics



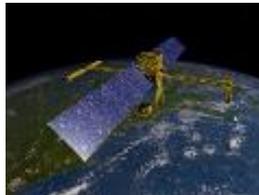
Magmatic Processes



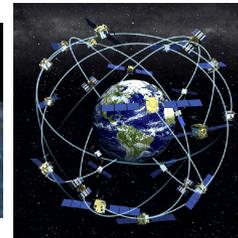
Surface Deformation



Time-Varying Magnetic Field



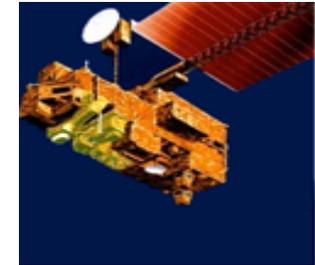
High Resolution Topography



Earth rotation and terrestrial reference frame (TRF)



Time-varying Gravity Field



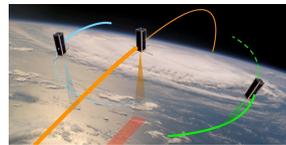
Hyperspectral Imaging



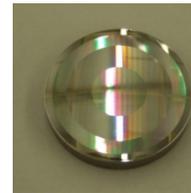
Active Microwave Sensors



Advanced GPS technologies



Precision Formation flying



TIR Sensors



Compact spectrometers



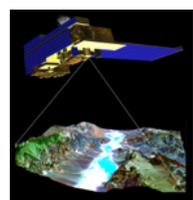
High end computing

JPL Earth Science Flight Projects

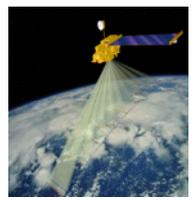
Operational



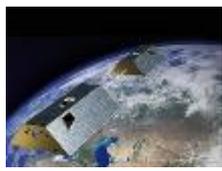
QuikSCAT
(1999)



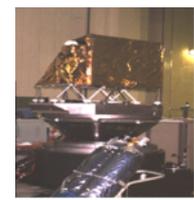
ASTER
(1999)



MISR
(1999)



GRACE
(2002)



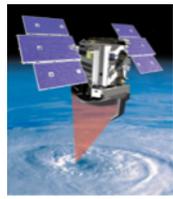
AIRS
(2002)



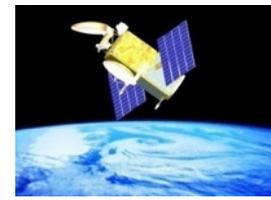
TES
(2004)



MLS
(2004)



CloudSat
(2006)



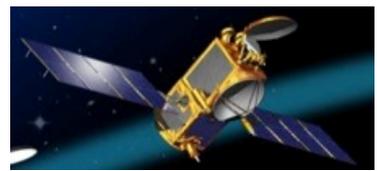
Ocean Surface
Topography Mission
(2008)



Carbon Cycle: OCO-2
(2014)

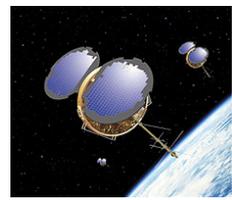


Soil Moisture: SMAP
(2015)



Jason 3⁽¹⁾ (2016)

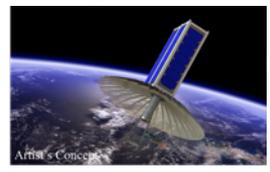
Formulation/Development



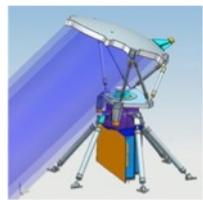
COSMIC-2 A/B⁽¹⁾⁽²⁾
(2017/2018)



GRACE-FO
(2017)



RainCube (2018)



COWVR⁽²⁾
(2017)



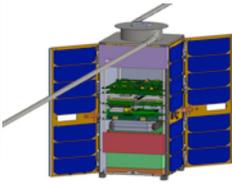
TEMPEST
(2018)



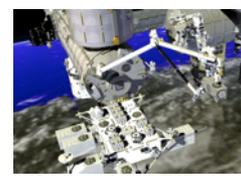
ECOSTRESS
(2018)



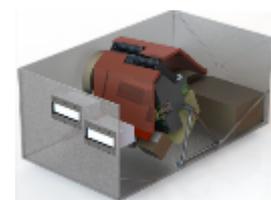
CIRAS
(~2018)



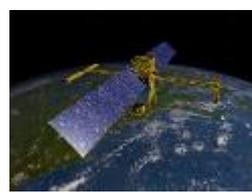
HF Research
(DHFR) Testbed⁽³⁾
(2018)



OCO-3
(2018)



MAIA
(2019+)



SWOT
(2021)



NISAR
(2021)



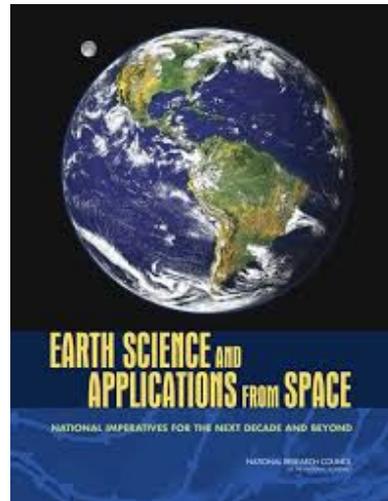
Sentinel 6
(2020/2025)

(1)NOAA
(2)USAF
(3)DARPA



2017 Decadal Survey

Looking Ahead



2007

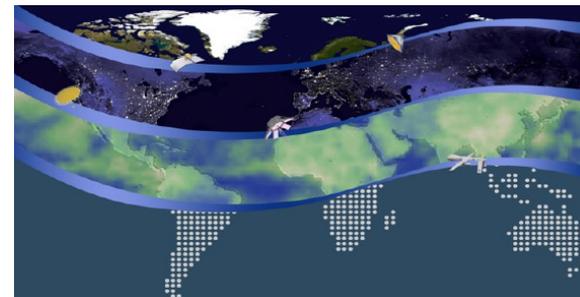


2017

Key Topics in the Statement of Task

- Balance between Sustained vs Research measurements
- Balance between Assigned vs Competed missions
- Balance between Science vs Applications
- Balance between Flight vs Non-Flight

7-10 Year Earth Science Trends



Individual
Science Results



Actionable Information

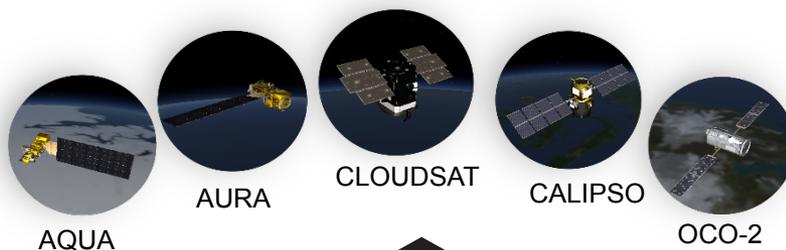
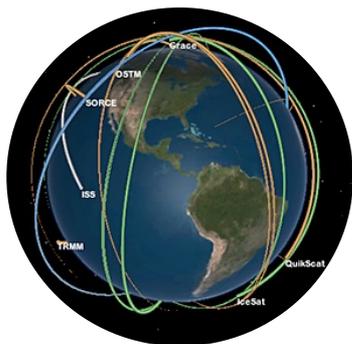
- Stakeholder engagement
- Increased spatial and temporal sampling
- Processing and assimilation of large volumes of disparate data
- Quantification of uncertainties for data sets and final products
- Measurement Continuity

Opportunistic
Multisensor
Data Sets



Coordinated observations/Constellations

- Increased opportunities for international partnerships
- Small commercial platforms
- Need for multiple advanced, but cost effective sensors



Science Station



Outcome

- Develop partnerships among science and technology community in advancing NASA Earth science
- Industry engagement in mass producing instruments for constellations
- Mobilize “science” workforce to address grand challenges through unimpeachable formulation and decision-support activities



Jet Propulsion Laboratory
California Institute of Technology